# EXHIBIT K

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**McLaughlin**

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(54) **GENERATING AN ENHANCED IMAGE OF A PREDETERMINED SCENE FROM A PLURALITY OF IMAGES OF THE PREDETERMINED SCENE**

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***G06T 3/40*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***G06T 3/4069*** (2013.01); ***G06T 5/00*** (2013.01); ***G06T 7/20*** (2013.01); ***G06T 7/30*** (2017.01);
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(Continued)

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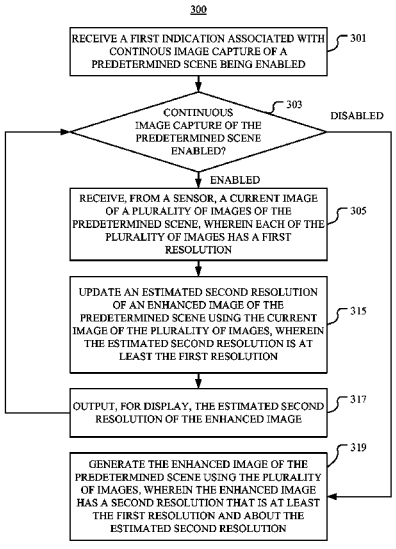
(57) **ABSTRACT**

A method, device, system, and article of manufacture are provided for generating an enhanced image of a predetermined scene from images. In one embodiment, a method comprises receiving, by a computing device, a first indication associated with continuous image capture of a predetermined scene being enabled; in response to the continuous image capture being enabled, receiving, by the computing device, from an image sensor, a reference image and a first image, wherein each of the reference image and the first image is of the predetermined scene and has a first resolution; determining an estimated second resolution of an enhanced image of the predetermined scene using the reference image and the first image; and in response to the continuous image capture being disabled, determining the enhanced image using the reference image and the first image, wherein the enhanced image has a second resolution that is at least the first resolution and about the estimated second resolution.

**20 Claims, 8 Drawing Sheets**



**Related U.S. Application Data**

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(51) **Int. Cl.**

| | |
|---|---|
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| ***G06T 7/20*** | (2017.01) |
| ***G06T 11/60*** | (2006.01) |
| ***G06T 7/30*** | (2017.01) |

(52) **U.S. Cl.**
CPC .... ***G06T 11/60*** (2013.01); *G06T 2207/20172* (2013.01); *G06T 2207/20221* (2013.01)

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See application file for complete search history.

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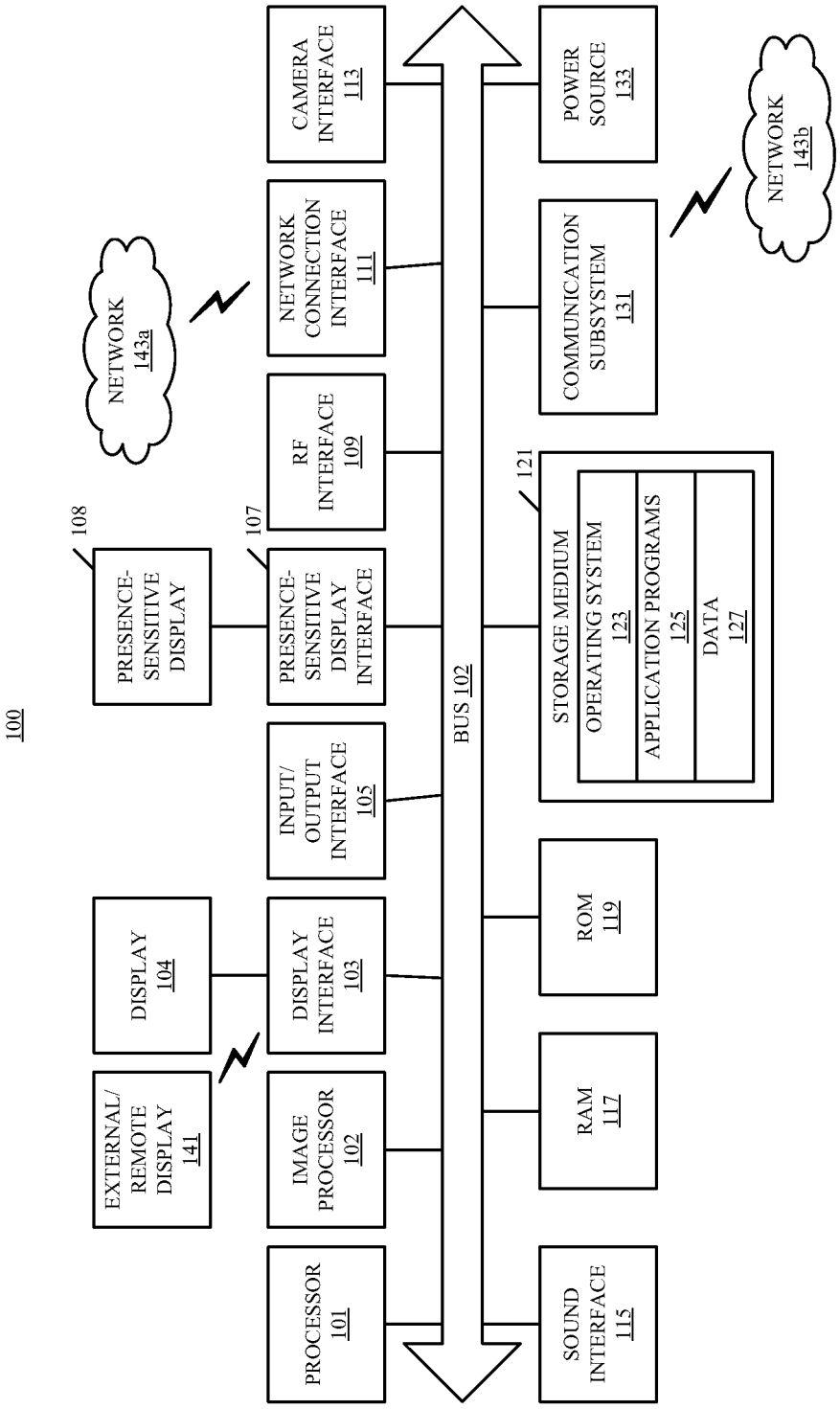
100
PROCESSOR 101
IMAGE PROCESSOR 102
DISPLAY INTERFACE 103
DISPLAY 104
EXTERNAL/ REMOTE DISPLAY 141
INPUT/ OUTPUT INTERFACE 105
PRESENCE-SENSITIVE DISPLAY INTERFACE 107
PRESENCE-SENSITIVE DISPLAY 108
RF INTERFACE 109
NETWORK CONNECTION INTERFACE 111
CAMERA INTERFACE 113
SOUND INTERFACE 115
RAM 117
ROM 119
STORAGE MEDIUM 121
OPERATING SYSTEM 123
APPLICATION PROGRAMS 125
DATA 127
COMMUNICATION SUBSYSTEM 131
POWER SOURCE 133
BUS 102
NETWORK 143a
NETWORK 143b

FIG. 1

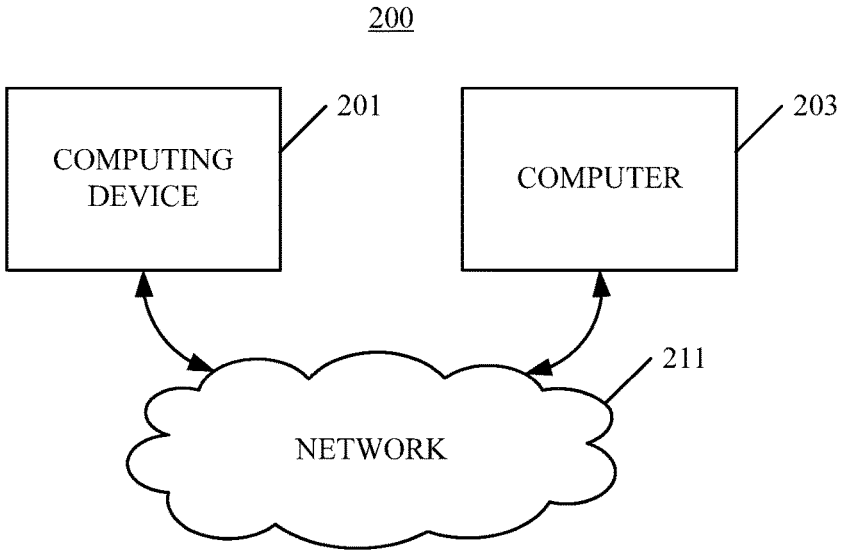


FIG. 2

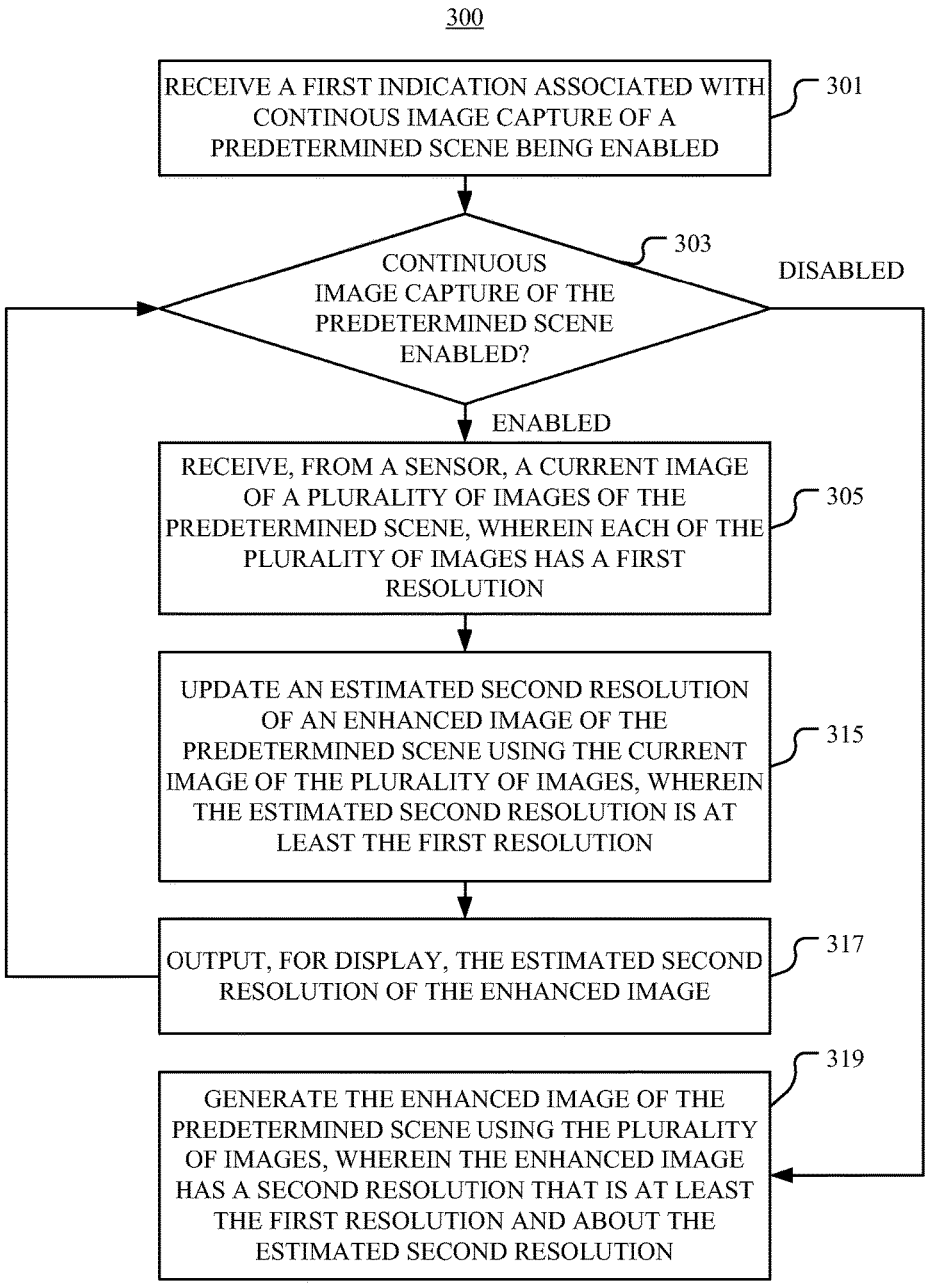
300
RECEIVE A FIRST INDICATION ASSOCIATED WITH CONTINOUS IMAGE CAPTURE OF A PREDETERMINED SCENE BEING ENABLED
301
CONTINUOUS IMAGE CAPTURE OF THE PREDETERMINED SCENE ENABLED?
303
DISABLED
ENABLED
RECEIVE, FROM A SENSOR, A CURRENT IMAGE OF A PLURALITY OF IMAGES OF THE PREDETERMINED SCENE, WHEREIN EACH OF THE PLURALITY OF IMAGES HAS A FIRST RESOLUTION
305
UPDATE AN ESTIMATED SECOND RESOLUTION OF AN ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE CURRENT IMAGE OF THE PLURALITY OF IMAGES, WHEREIN THE ESTIMATED SECOND RESOLUTION IS AT LEAST THE FIRST RESOLUTION
315
OUTPUT, FOR DISPLAY, THE ESTIMATED SECOND RESOLUTION OF THE ENHANCED IMAGE
317
GENERATE THE ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE PLURALITY OF IMAGES, WHEREIN THE ENHANCED IMAGE HAS A SECOND RESOLUTION THAT IS AT LEAST THE FIRST RESOLUTION AND ABOUT THE ESTIMATED SECOND RESOLUTION
319

FIG. 3

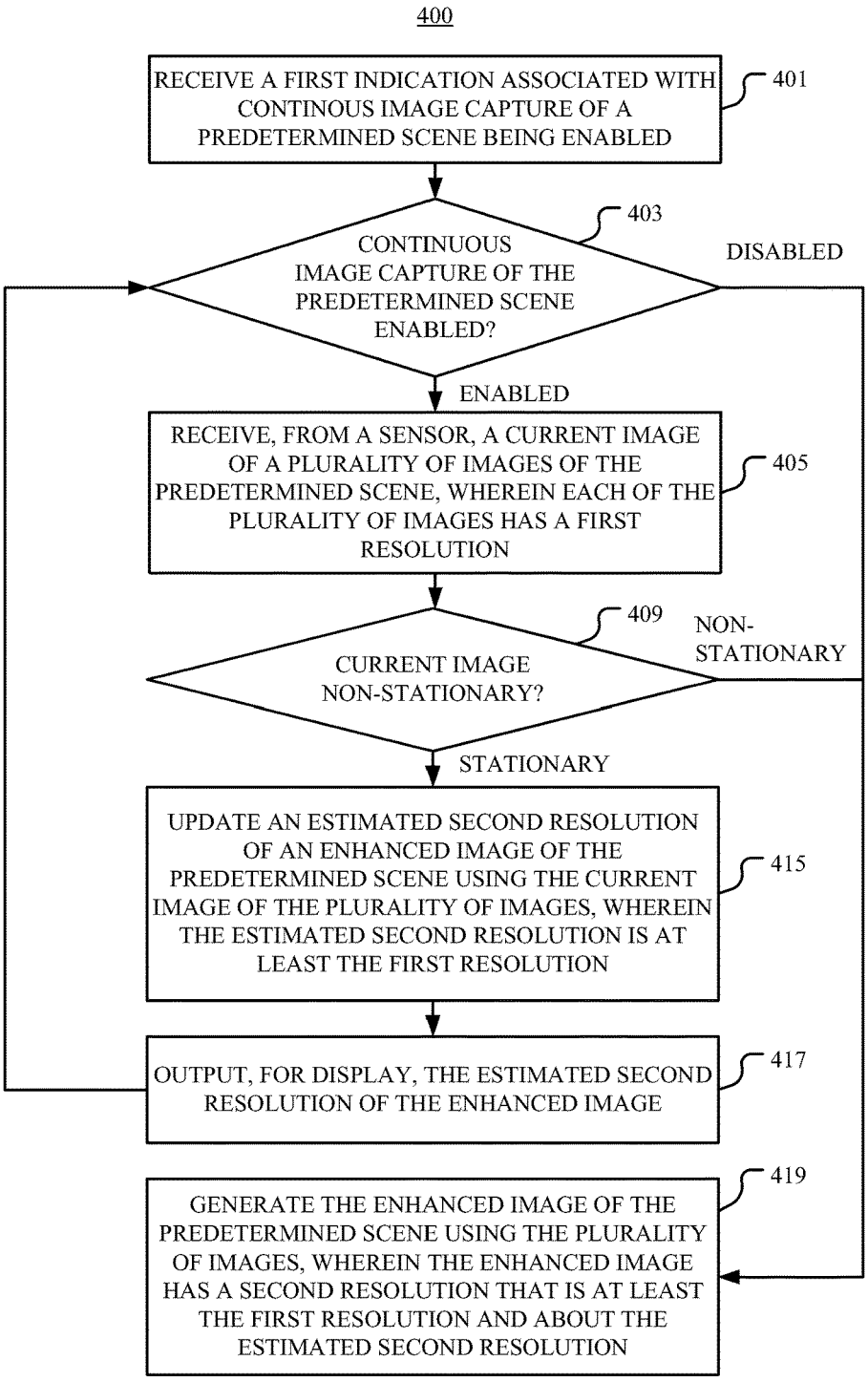
400
RECEIVE A FIRST INDICATION ASSOCIATED WITH CONTINOUS IMAGE CAPTURE OF A PREDETERMINED SCENE BEING ENABLED
401
CONTINUOUS IMAGE CAPTURE OF THE PREDETERMINED SCENE ENABLED?
403
DISABLED
ENABLED
RECEIVE, FROM A SENSOR, A CURRENT IMAGE OF A PLURALITY OF IMAGES OF THE PREDETERMINED SCENE, WHEREIN EACH OF THE PLURALITY OF IMAGES HAS A FIRST RESOLUTION
405
CURRENT IMAGE NON-STATIONARY?
409
NON-STATIONARY
STATIONARY
UPDATE AN ESTIMATED SECOND RESOLUTION OF AN ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE CURRENT IMAGE OF THE PLURALITY OF IMAGES, WHEREIN THE ESTIMATED SECOND RESOLUTION IS AT LEAST THE FIRST RESOLUTION
415
OUTPUT, FOR DISPLAY, THE ESTIMATED SECOND RESOLUTION OF THE ENHANCED IMAGE
417
GENERATE THE ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE PLURALITY OF IMAGES, WHEREIN THE ENHANCED IMAGE HAS A SECOND RESOLUTION THAT IS AT LEAST THE FIRST RESOLUTION AND ABOUT THE ESTIMATED SECOND RESOLUTION
419

FIG. 4

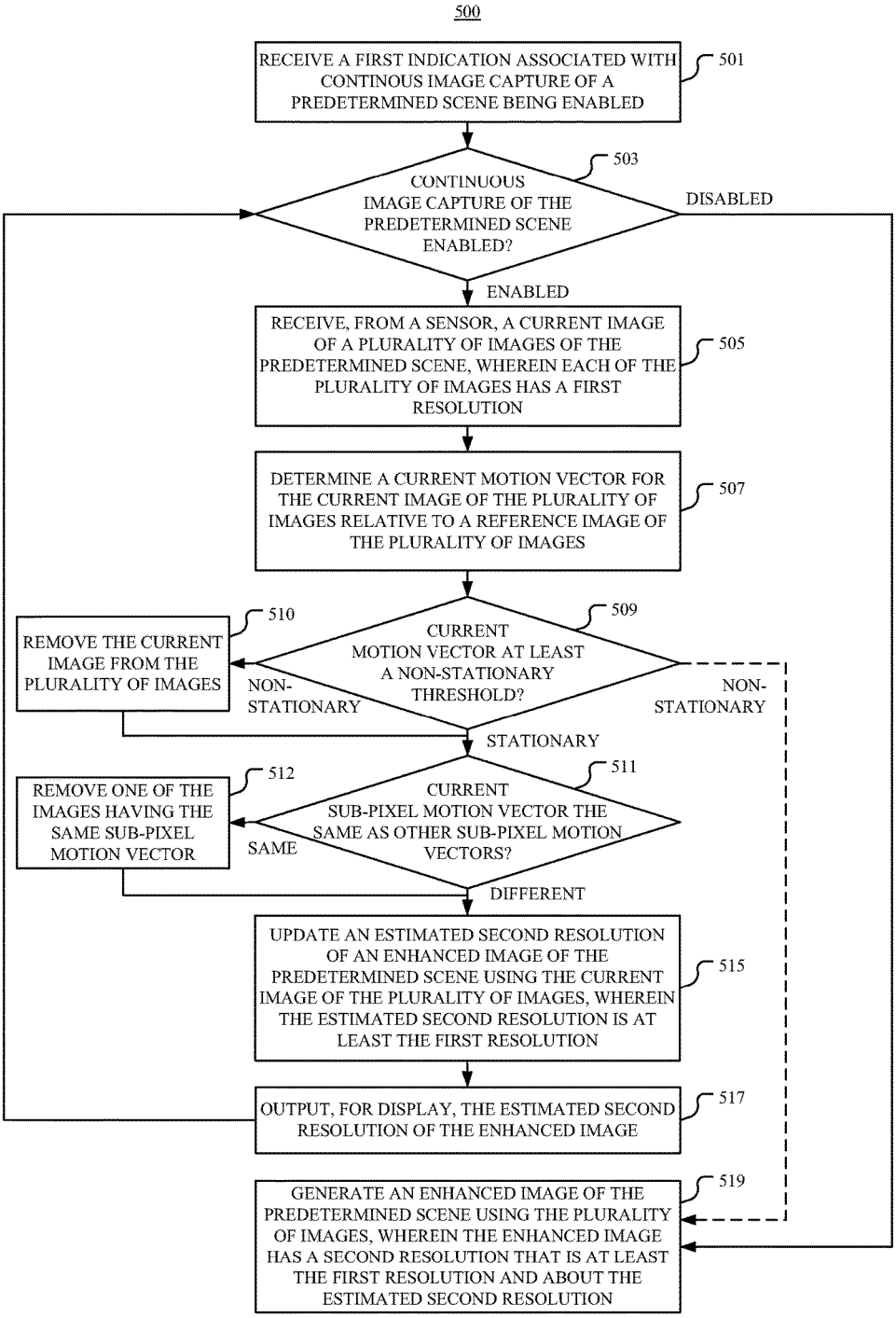
500
RECEIVE A FIRST INDICATION ASSOCIATED WITH CONTINOUS IMAGE CAPTURE OF A PREDETERMINED SCENE BEING ENABLED
501
CONTINUOUS IMAGE CAPTURE OF THE PREDETERMINED SCENE ENABLED?
503
DISABLED
ENABLED
RECEIVE, FROM A SENSOR, A CURRENT IMAGE OF A PLURALITY OF IMAGES OF THE PREDETERMINED SCENE, WHEREIN EACH OF THE PLURALITY OF IMAGES HAS A FIRST RESOLUTION
505
DETERMINE A CURRENT MOTION VECTOR FOR THE CURRENT IMAGE OF THE PLURALITY OF IMAGES RELATIVE TO A REFERENCE IMAGE OF THE PLURALITY OF IMAGES
507
CURRENT MOTION VECTOR AT LEAST A NON-STATIONARY THRESHOLD?
509
NON-STATIONARY
REMOVE THE CURRENT IMAGE FROM THE PLURALITY OF IMAGES
510
NON-STATIONARY
STATIONARY
CURRENT SUB-PIXEL MOTION VECTOR THE SAME AS OTHER SUB-PIXEL MOTION VECTORS?
511
SAME
REMOVE ONE OF THE IMAGES HAVING THE SAME SUB-PIXEL MOTION VECTOR
512
DIFFERENT
UPDATE AN ESTIMATED SECOND RESOLUTION OF AN ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE CURRENT IMAGE OF THE PLURALITY OF IMAGES, WHEREIN THE ESTIMATED SECOND RESOLUTION IS AT LEAST THE FIRST RESOLUTION
515
OUTPUT, FOR DISPLAY, THE ESTIMATED SECOND RESOLUTION OF THE ENHANCED IMAGE
517
GENERATE AN ENHANCED IMAGE OF THE PREDETERMINED SCENE USING THE PLURALITY OF IMAGES, WHEREIN THE ENHANCED IMAGE HAS A SECOND RESOLUTION THAT IS AT LEAST THE FIRST RESOLUTION AND ABOUT THE ESTIMATED SECOND RESOLUTION
519

FIG. 5

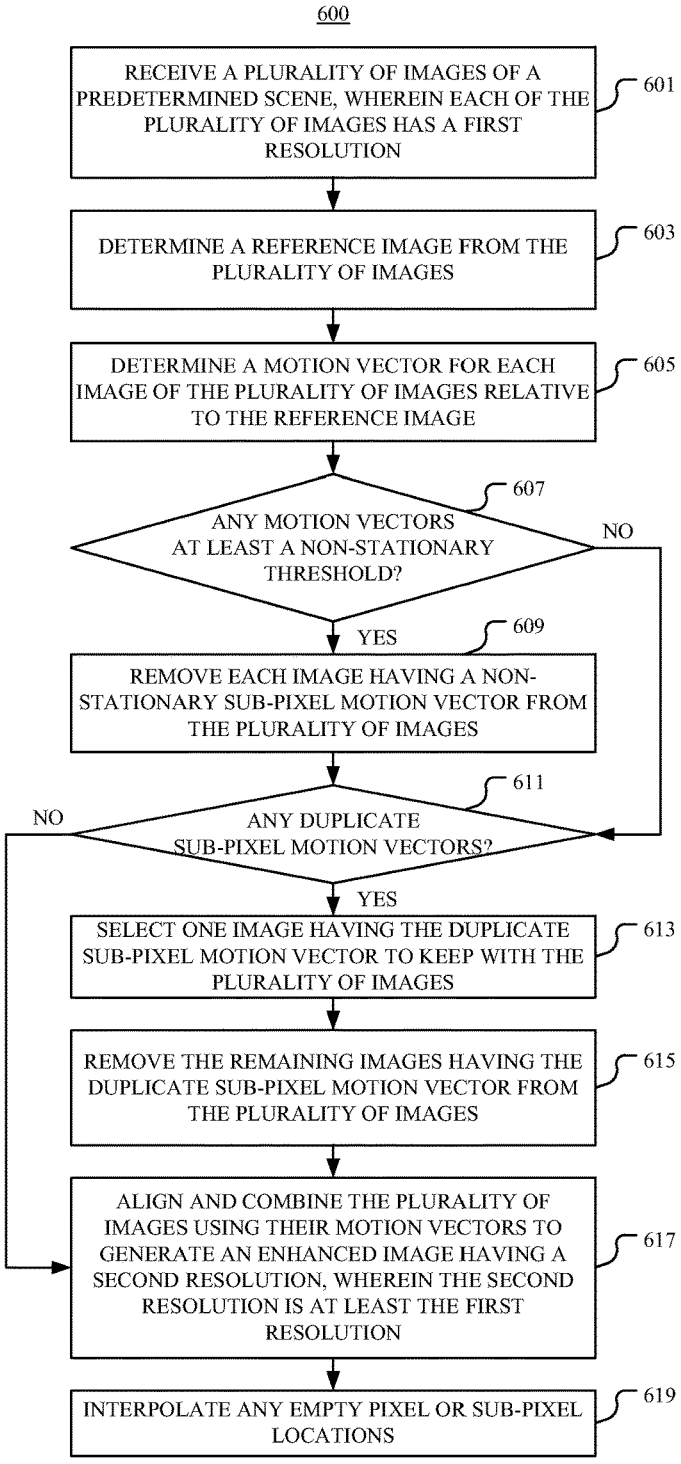
600
RECEIVE A PLURALITY OF IMAGES OF A PREDETERMINED SCENE, WHEREIN EACH OF THE PLURALITY OF IMAGES HAS A FIRST RESOLUTION
601
DETERMINE A REFERENCE IMAGE FROM THE PLURALITY OF IMAGES
603
DETERMINE A MOTION VECTOR FOR EACH IMAGE OF THE PLURALITY OF IMAGES RELATIVE TO THE REFERENCE IMAGE
605
ANY MOTION VECTORS AT LEAST A NON-STATIONARY THRESHOLD?
607
NO
YES
REMOVE EACH IMAGE HAVING A NON-STATIONARY SUB-PIXEL MOTION VECTOR FROM THE PLURALITY OF IMAGES
609
ANY DUPLICATE SUB-PIXEL MOTION VECTORS?
611
NO
YES
SELECT ONE IMAGE HAVING THE DUPLICATE SUB-PIXEL MOTION VECTOR TO KEEP WITH THE PLURALITY OF IMAGES
613
REMOVE THE REMAINING IMAGES HAVING THE DUPLICATE SUB-PIXEL MOTION VECTOR FROM THE PLURALITY OF IMAGES
615
ALIGN AND COMBINE THE PLURALITY OF IMAGES USING THEIR MOTION VECTORS TO GENERATE AN ENHANCED IMAGE HAVING A SECOND RESOLUTION, WHEREIN THE SECOND RESOLUTION IS AT LEAST THE FIRST RESOLUTION
617
INTERPOLATE ANY EMPTY PIXEL OR SUB-PIXEL LOCATIONS
619

FIG. 6

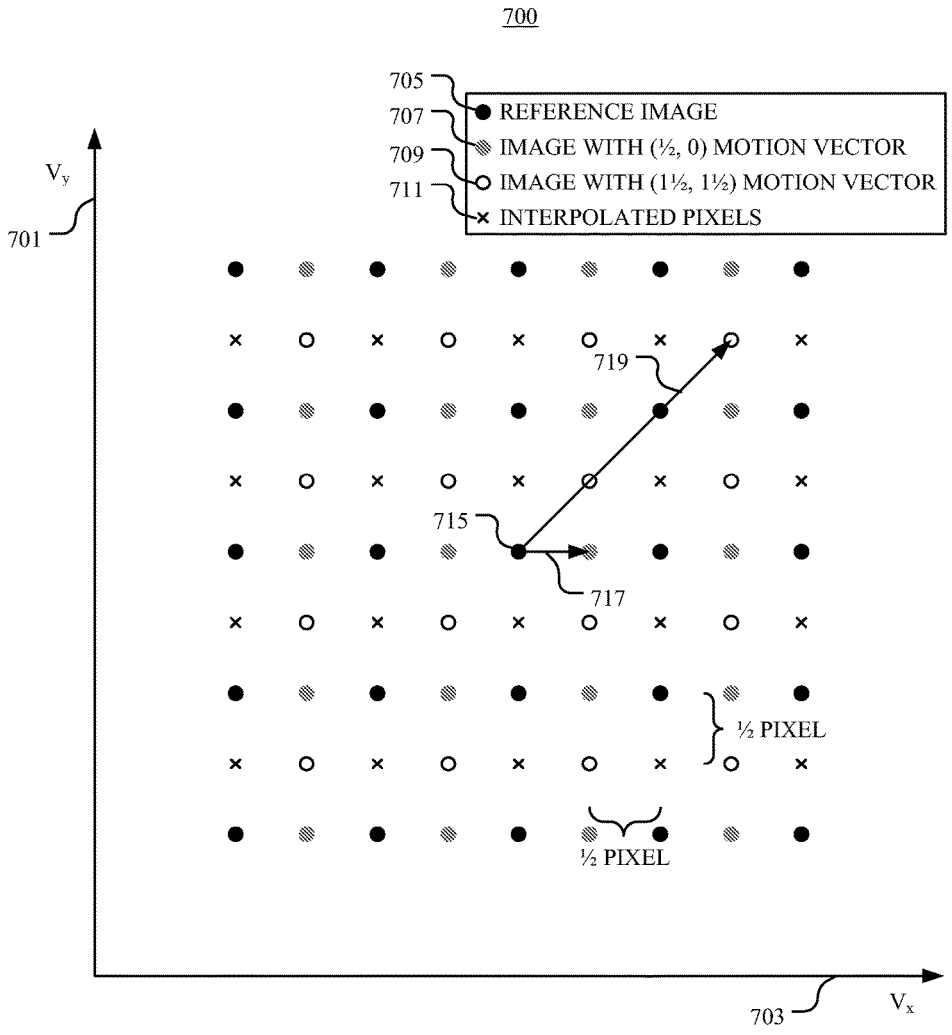
700
705
707
709
711
REFERENCE IMAGE
IMAGE WITH (½, 0) MOTION VECTOR
IMAGE WITH (1½, 1½) MOTION VECTOR
INTERPOLATED PIXELS
$V_y$
701
719
715
717
½ PIXEL
½ PIXEL
703
$V_x$

FIG. 7

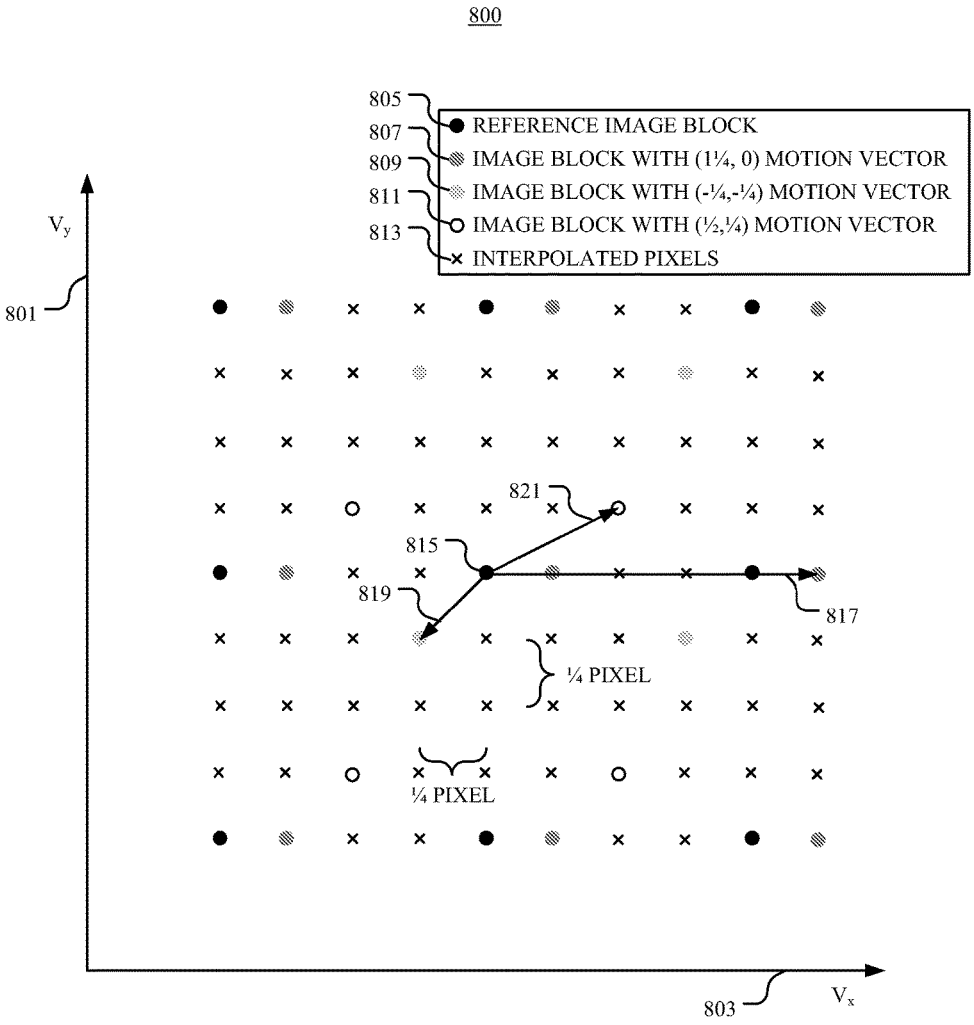
800
805
807
809
811
813
REFERENCE IMAGE BLOCK
IMAGE BLOCK WITH (1¼, 0) MOTION VECTOR
IMAGE BLOCK WITH (-¼,-¼) MOTION VECTOR
IMAGE BLOCK WITH (½,¼) MOTION VECTOR
INTERPOLATED PIXELS
$V_y$
801
821
815
819
817
¼ PIXEL
¼ PIXEL
803
$V_x$

FIG. 8

# GENERATING AN ENHANCED IMAGE OF A PREDETERMINED SCENE FROM A PLURALITY OF IMAGES OF THE PREDETERMINED SCENE

## RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 14/269,762, filed May 5, 2014, which claims priority and benefit under 35 U.S.C. § 119(e) from U.S. Provisional Patent Application No. 61/915,286, filed Dec. 12, 2013, the contents of which are incorporated herein by reference in their entirety.

## FIELD OF USE

The embodiments described herein relate to generating higher resolution images and more particularly to generating an enhanced image of a predetermined scene from plurality of images of the predetermined scene.

## BACKGROUND

Images with higher resolutions are typically considered more desirable. An enhanced image shows greater detail than a lower resolution image of the same scene. Super-resolution image processing uses multiple lower resolution images of a scene to generate an enhanced image of the scene. The multiple lower resolution images may be captured by the same camera and may represent different views of the same scene. The enhanced image may be generated by aligning and combining the multiple lower resolution images so that additional image information is obtained. Since super-resolution image processing is computationally intensive, super-resolution image processing has been typically applied in industrial applications such as medical imaging, face recognition, computer vision and satellite imaging.

## BRIEF DESCRIPTION OF THE FIGURES

The present disclosure is illustrated by way of examples, embodiments and the like and is not limited by the accompanying figures, in which like reference numbers indicate similar elements. Elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. The figures along with the detailed description are incorporated and form part of the specification and serve to further illustrate examples, embodiments and the like, and explain various principles and advantages, in accordance with the present disclosure, where:

FIG. **1** is a block diagram illustrating one embodiment of a computing device in accordance with various aspects set forth herein.

FIG. **2** illustrates one embodiment of a system for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein.

FIG. **3** is a flowchart of one embodiment of a method for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein.

FIG. **4** is a flowchart of another embodiment of a method for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein.



FIG. **5** is a flowchart of another embodiment of a method for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein.

FIG. **6** is a flowchart of another embodiment of a method for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein.

FIG. **7** provides an example of a two-dimensional grid used to generate an enhanced image of a predetermined scene from a plurality of images of the predetermined scene in accordance with various aspects described herein.

FIG. **8** provides another example of a two-dimensional grid used to generate an enhanced image of a predetermined scene from a plurality of images of the predetermined scene in accordance with various aspects described herein.

## DETAILED DESCRIPTION

This disclosure provides example methods, devices (or apparatuses), systems, or articles of manufacture for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene. By configuring a computing device in accordance with various aspects described herein, increased usability of the computing device is provided. For example, a user may position a camera in preparation to capture a scene and then may press and hold a button of the camera to capture the scene. While the button is depressed, the camera may continuously capture images of the scene. Further, while the button is depressed, the camera may display an estimated resolution of an enhanced image associated with captured images of the scene. Once the user releases the button, the camera may no longer capture images of the scene and may generate an enhanced image from the captured images. The enhanced image may have a resolution that is about the estimated resolution.

In another example, a user may enable a super-resolution image mode of a smartphone. While in super-resolution image mode, in response to the user taking a picture of a scene using the smartphone, the camera may continuously capture images of the scene until an estimated resolution of an enhanced image associated with the captured images of the scene is reached. Once the estimated resolution of the enhanced image is reached, the smartphone may generate an enhanced image using the captured images. The enhanced image may have a resolution that is about the estimated resolution.

In another example, while capturing a burst of images of a scene, a tablet computer may select one of the captured images as a reference image of the scene. Further, the tablet computer may determine a sub-pixel motion vector for each captured image relative to the reference image. For any captured images having the same sub-pixel motion vector, the tablet computer may select one of these captured images and may remove the others. The tablet computer may then generate an enhanced image from the remaining captured images.

In another example, while capturing a burst of images of a scene, a wearable device may select one of the captured images as a reference image of the scene. Further, the wearable device may determine a sub-pixel motion vector for each captured image relative to the reference image. For any captured image having a sub-pixel motion vector that is associated with motion of subject matter in the scene, the wearable device may remove such captured image or may

no longer capture images of the scene. The wearable device may then generate an enhanced image from the remaining captured images.

In another example, an image processor may receive captured images of a scene including a reference image of the scene. The image processor may determine a sub-pixel motion vector for each captured image relative to the reference image. For any captured images having the same sub-pixel motion vector, the image processor may select one of these captured images and may remove the others. The image processor may then align and combine the captured images using their sub-pixel motion vectors to form an enhanced image. Further, the image processor may perform interpolation on any empty sub-pixel locations of the enhanced image.

A presence-sensitive input device as discussed herein, may be a device that accepts input by the proximity of a finger, a stylus or an object near the device, detects gestures without physically touching the device, or detects eye or eye lid movements or facial expressions of a user operating the device. Additionally, a presence-sensitive input device may be combined with a display to provide a presence-sensitive display. In one example, a user may provide an input to a computing device by touching the surface of a presence-sensitive display using a finger. In another example, a user may provide input to a computing device by gesturing without physically touching any object. In another example, a gesture may be received via a digital camera, a digital video camera, or a depth camera. In another example, an eye or eye lid movement or a facial expression may be received using a digital camera, a digital video camera or a depth camera and may be processed using eye tracking technology, which may determine a gaze location on a display or a virtual display. In some instances, the eye tracking technology may use an emitter operationally coupled to a computing device to produce infrared or near-infrared light for application to one or both eyes of a user of the computing device. In one example, the emitter may produce infrared or near-infrared non-collimated light. A person of ordinary skill in the art will recognize various techniques for performing eye tracking.

In some instances, a presence-sensitive display can have two main attributes. First, it may enable a user to interact directly with what is displayed, rather than indirectly via a pointer controlled by a mouse or touchpad. Secondly, it may allow a user to interact without requiring any intermediate device that would need to be held in the hand. Such displays may be attached to computers, or to networks as terminals. Such displays may also play a prominent role in the design of digital appliances such as the personal digital assistant (PDA), satellite navigation devices, mobile phones, video games, and wearable devices such as a pair of glasses having a virtual display or a watch. Further, such displays may include a capture device and a display.

According to one example implementation, the terms computing device or mobile computing device, as used herein, may be a central processing unit (CPU), controller or processor, or may be conceptualized as a CPU, controller or processor (for example, the processor **101** of FIG. **1**). In yet other instances, a computing device may be a CPU, controller or processor combined with one or more additional hardware components. In certain example implementations, the computing device operating as a CPU, controller or processor may be operatively coupled with one or more peripheral devices, such as a display, navigation system, stereo, entertainment center, Wi-Fi access point, or the like. In another example implementation, the term computing device or portable computing device, as used herein, may refer to a mobile communication device, such as a smartphone, mobile station (MS), terminal, cellular phone, cellular handset, personal digital assistant (PDA), smartphone, wireless phone, organizer, handheld computer, desktop computer, laptop computer, tablet computer, set-top box, television, appliance, game device, medical device, display device, wearable device or some other like terminology. In one example, the computing device may output content to its local display or virtual display, or speaker(s). In another example, the computing device may output content to an external display device (e.g., over Wi-Fi) such as a TV, a virtual display of a wearable device, or an external computing device.

FIG. **1** is a block diagram illustrating one embodiment of a computing device **100** in accordance with various aspects set forth herein. In FIG. **1**, the computing device **100** may be configured to include a processor **101**, which may also be referred to as a computing device, that is operatively coupled to an image processor **102**, a display interface **103**, an input/output interface **105**, a presence-sensitive display interface **107**, a radio frequency (RE) interface **109**, a network connection interface **111**, a camera interface **113**, a sound interface **115**, a random access memory (RAM) **117**, a read only memory (ROM) **119**, a storage medium **121**, an operating system **123**, an application program **125**, data **127**, a communication subsystem **131**, a power source **133**, another element, or any combination thereof. In FIG. **1**, the processor **101** may be configured to process computer instructions and data. The processor **101** may be configured to be a computer processor or a controller. For example, the processor **101** may include two computer processors. In one definition, data is information in a form suitable for use by a computer. It is important to note that a person having ordinary skill in the art will recognize that the subject matter of this disclosure may be implemented using various operating systems or combinations of operating systems. The image processor **102** may be configured to perform digital image processing on digital image data. The image processor **102** may perform digital image processing such as discrete cosine transforms, inverse discrete cosine transforms, classification, feature extraction, pattern recognition, projection, multi-scale signal analysis, pixilation, filtering, component analysis, Markov models, anisotropic diffusion, interpolation such as bilinear interpolation and bicubic interpolation, oversampling, motion estimation, motion compensation, or the like. Further, the image processor **102** may be configured to perform digital video processing on digital video data. The image processor **102** may perform digital video processing such as deinterlacing, aspect ratio control, digital zoom and pan, brightness, contrast, hue, saturation, sharpness and gamma adjustments, frame rate conversion, color point conversion, color space conversion, noise reduction, detail enhancement, edge enhancement, motion compensation, color calibration, or the like the like. Further, the image processor **102** may perform various video encoding and decoding algorithms such as MPEG-1, MPEG-2, MPEG-4, H.264, DivX, or the like. Also, the image processor **102** may be configured to perform the functions of a graphics processing unit (GPU) such as three-dimensional computer graphics, texture mapping, polygon rendering, geometric calculations, shading, aliasing, or the like.

In FIG. **1**, the display interface **103** may be configured as a communication interface and may provide functions for rendering video, graphics, images, text, other information, or any combination thereof on a display **104**. In one example, a communication interface may include a serial

port, a parallel port, a general purpose input and output (GPIO) port, a game port, a universal serial bus (USB), a micro-USB port, a high definition multimedia (HDMI) port, a video port, an audio port, a Bluetooth port, a near-field communication (NEC) port, another like communication interface, or any combination thereof. In one example, the display interface **103** may be operatively coupled to display **104** such as a touch-screen display associated with a mobile device or a virtual display associated with a wearable device. In another example, the display interface **103** may be configured to provide video, graphics, images, text, other information, or any combination thereof for an external/remote display **141** that is not necessarily connected to the computing device. In one example, a desktop monitor may be utilized for mirroring or extending graphical information that may be presented on a mobile device. In another example, the display interface **103** may wirelessly communicate, for example, via the network connection interface **111** such as a Wi-Fi transceiver to the external/remote display **141**.

In the current embodiment, the input/output interface **105** may be configured to provide a communication interface to an input device, output device, or input and output device. The computing device **100** may be configured to use an output device via the input/output interface **105**. A person of ordinary skill will recognize that an output device may use the same type of interface port as an input device. For example, a USB port may be used to provide input to and output from the computing device **100**. The output device may be a speaker, a sound card, a video card, a display, a monitor, a printer, an actuator, an emitter, a smartcard, another output device, or any combination thereof. In one example, the emitter may be an infrared emitter. In another example, the emitter may be an emitter used to produce infrared or near-infrared non-collimated light, which may be used for eye tracking. The computing device **100** may be configured to use an input device via the input/output interface **105** to allow a user to capture information into the computing device **100**. The input device may include a mouse, a trackball, a directional pad, a trackpad, a presence-sensitive input device, a presence-sensitive display, a scroll wheel, a digital camera, a digital video camera, a web camera, a microphone, a sensor, a smartcard, and the like. The presence-sensitive input device may include a sensor, or the like to sense input from a user. The presence-sensitive input device may be combined with a display to form a presence-sensitive display. Further, the presence-sensitive input device may be coupled to the computing device. The sensor may be, for instance, a digital camera, a digital video camera, a depth camera, a web camera, a microphone, an accelerometer, a gyroscope, a tilt sensor, a three sensor, a magnetometer, an optical sensor, a proximity sensor, another like sensor, or any combination thereof. For example, the input device **115** may be an accelerometer, a magnetometer, a digital camera, a microphone, and an optical sensor. An image sensor may be a digital camera, a digital video camera, a depth camera, a web camera, an optical sensor, an active pixel sensor, or the like.

In FIG. **1**, the presence-sensitive display interface **107** may be configured to provide a communication interface to a pointing device or a presence-sensitive display **108** such as a touch screen. In one definition, a presence-sensitive display is an electronic visual display that may detect the presence and location of a touch, a gesture, an eye or eye lid movement, a facial expression or an object associated with its display area. The RF interface **109** may be configured to provide a communication interface to RF components such as a transmitter, a receiver, and an antenna. The network connection interface **111** may be configured to provide a communication interface to a network **143***a*. The network **143***a* may encompass wired and wireless communication networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, the network **143***a* may be a cellular network, a network, and a near-field network. As previously discussed, the display interface **103** may be in communication with the network connection interface **111**, for example, to provide information for display on a remote display that is operatively coupled to the computing device **100**. The camera interface **113** may be configured to provide a communication interface and functions for capturing digital images or video from a camera. The sound interface **115** may be configured to provide a communication interface to a microphone or speaker.

In this embodiment, the RAM **117** may be configured to interface via the bus **102** to the processor **101** to provide storage or caching of data or computer instructions during the execution of software programs such as the operating system, application programs, and device drivers. In one example, the computing device **100** may include at least one hundred and twenty-eight megabytes (128 Mbytes) of RAM. The ROM **119** may be configured to provide computer instructions or data to the processor **101**. For example, the ROM **119** may be configured to be invariant low-level system code or data for basic system functions such as basic input and output (I/O), startup, or reception of keystrokes from a keyboard that are stored in a non-volatile memory. The storage medium **121** may be configured to include memory such as RAM, ROM, programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), magnetic disks, optical disks, floppy disks, hard disks, removable cartridges, flash drives. In one example, the storage medium **121** may be configured to include an operating system **123**, an application program **125** such as a web browser application, a widget or gadget engine or another application, and a data file **127**.

In FIG. **1**, the computing device **101** may be configured to communicate with a network **143***b* using the communication subsystem **131**. The network **143***a* and the network **143***b* may be the same network or networks or different network or networks. The communication functions of the communication subsystem **131** may include data communication, voice communication, multimedia communication, short-range communications such as Bluetooth, near-field communication, location-based communication such as the use of the global positioning system. (GPS) to determine a location, another like communication function, or any combination thereof. For example, the communication subsystem **131** may include cellular communication, Wi-Fi communication, Bluetooth communication, and GPS communication. The network **143***b* may encompass wired and wireless communication networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, the network **143***b* may be a cellular network, a Wi-Fi network, and a near-field network. The power source **133** may be configured to provide an alternating current (AC) or direct current (DC) power to components of the computing device **100**.

In FIG. **1**, the storage medium **121** may be configured to include a number of physical drive units, such as a redundant array of independent disks (RAID), a floppy disk drive, a flash memory, a USB flash drive, an external hard disk drive, thumb drive, pen drive, key drive, a high-density digital versatile disc (HD-DVD) optical disc drive, an internal hard disk, drive, a Blu-Ray optical disc drive, a holographic digital data storage (HDDS) optical disc drive, an external mini-dual in-line memory module (DIMM) synchronous dynamic random access memory (SDRAM), an external micro-DIMM SDRAM, a smartcard memory such as a subscriber identity module or a removable user identity (SIM/RUIM) module, other memory, or any combination thereof. The storage medium **121** may allow the computing device **100** to access computer-executable instructions, application programs or the like, stored on transitory or non-transitory memory media, to off-load data, or to upload data. An article of manufacture, such as one utilizing a communication system may be tangibly embodied in storage medium **122**, which may comprise a computer-readable medium.

FIG. **2** illustrates one embodiment of a system **200** for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein. In FIG. **2**, the system **200** may be configured to include a computing device **201**, a computer **203**, and a network **211**. The computer **203** may be configured to process requests or provide data to the computing device **201** over a network **211**. The computer **203** may be configured to include a computer software system. In one example, the computer **203** may be a computer software system executing on a computer hardware system. The computer **203** may execute one or more services. Further, the computer **203** may include one or more computer programs running to serve requests or provide data to local computer programs executing on the computer **203** or remote computer programs executing on the computing device **201**. The computer **203** may be capable of performing functions associated with a server such as a database server, a file server, a mail server, a print server, a web server, a gaming server, the like, or any combination thereof, whether in hardware or software. In one example, the computer **203** may be a web server. In another example, the computer **203** may be a file server. Also, the computer **203** may be capable of performing image processing functions.

In FIG. **2**, the network **211** may include wired or wireless communication networks such as a local-area network (LAN), a wide-area network (WAN), a computer network, a wireless network, a telecommunications network, the like or any combination thereof. In one example, the network **211** may be a cellular network, a Wi-Fi network, and the Internet. The computing device **201** may communicate with the computer **203** using the network **211**. The computing device **201** may refer to a mobile communication device such as a smartphone, a mobile station (MS), a terminal, a cellular phone, a cellular handset, a personal digital assistant (PDA), a wireless phone, an organizer, a handheld computer, a desktop computer, a laptop computer, a tablet computer, a set-top box, a television, an appliance, a game device, a medical device, a display device, a wearable device, or the like.

In one embodiment, the computing device **201** may receive a first indication associated with continuous image capture of a predetermined scene being enabled. In one example, the continuous image capture of the predetermined scene may be associated with capturing sequential images of the predetermined scene. In another example, the predetermined scene may be associated with a user positioning the computing device **201** so that an image sensor of the computing device **201** may capture plurality of images. In response to the continuous image capture of the predetermined scene being enabled, the computing device **201** may capture a current image of a plurality of images of the predetermined scene. In one example, a user of the computing device **201** may be holding the computing device **201** while the plurality of images of the predetermined scene are captured. Each of the plurality of images may have a first resolution. Further, each of the plurality of images may be a raw image. In one example, the first resolution may be associated with a resolution of the image sensor.

Furthermore, the computing device **201** may update an estimated second resolution of an enhanced image of the predetermined scene using the current image of the plurality of images. In one example, the computing device **201** may update the estimated second resolution of the enhanced image by increasing it by the first resolution of the current image. In another example, the computing device **201** may update the estimated second resolution by a portion of the first resolution of the current image. The second resolution of the enhanced image may be at least the first resolution of the current image of the plurality of images. The computing device **201** may output, for display, the estimated second resolution of the enhanced image. In one example, a user may view the estimated second resolution on a display of the computing device **201**. In another example, a user may view the estimated second resolution on a display of the computing device **201** while the computing device **201** is receiving the plurality of images. The computing device **201** may determine that the continuous image capture is disabled. In one example, the computing device **201** may receive a second indication associated with the continuous image capture of the predetermined scene being disabled.

In another embodiment, the computing device **201** may determine that the estimated second resolution of the enhanced image is at least a predetermined resolution. The predetermined resolution may be at least the first resolution of the current image of the plurality of images, set by a user of the computing device **201**, at least double the first resolution of the current image of the plurality of images, or the like. In response to determining that the estimated second resolution of the enhanced image is at least the predetermined resolution, the computing device **201** may disable the continuous image capture.

In another embodiment, the computing device **201** may determine that a first duration associated with the continuous image capture of the predetermined scene is at least a predetermined duration. The predetermined duration may be associated with capturing a certain number of images of the plurality of images. In response to determining that the second duration is at least the predetermined duration, the computing device **201** may disable the continuous image capture.

In another embodiment, the computing device **201** may determine that a number of images of the plurality of images received by the computing device **201** is at least a predetermined number of images of the plurality of images. The predetermined number of images of the plurality of images may be associated with performing a burst mode of a camera of the computing device **201**. In response to determining that the number of images of the plurality of images received by the computing device **201** is at least the predetermined number of images of the plurality of images, the computing device **201** may disable the continuous image capture of the predetermined scene.

In another embodiment, the computing device **201** may determine that the current image of the plurality of images is non-stationary, which may indicate movement of certain subject matter in the scene. Since the enhanced image may be generated by aligning and combining the plurality of images so that additional image information is obtained, any motion of certain subject matter in the scene may degrade the quality of the enhanced image. Thus, the computing device **201** may detect motion in the current image of the plurality of images and, in response to detecting motion, may disable the continuous image capture of the predetermine scene or may remove the current image from the plurality of images.

In another embodiment, in response to the continuous image capture of the predetermined scene being disabled, the computing device **201** may generate the enhanced image of the predetermined scene using the plurality of images. In one example, the computing device **201** may output, to an image processor, the plurality of images. In response, the computing device **201** may receive, from the image processor, the enhanced image. In another example, the computing device **201** may output, to a computer, the plurality of images. In response, the computing device **201** may receive, from the computer, the enhanced image.

In another embodiment, the computing device **201** may determine a sub-pixel motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. The computing device **201** may decompose all or a portion of the current image of the plurality of images into image blocks, which may also be referred to as macroblocks. In one example, the image block may be four (4) pixels by four (4) pixels, eight (8) pixels by eight (8) pixels, sixteen (16) pixels by sixteen (16) pixels, or the like. In another example, an image may be an image block. The computing device **201** may determine for each image block of the current image a best match to an image block of the reference image. The two-dimensional coordinate shift of each image block of the current image relative to a best image block of the reference image may determine an integer pixel motion vector for the current image. However, during the continuous image capture, an image sensor of the computing device **201**, objects in the predetermined scene, or the like may not move in exact integer pixel increments. Instead, the image sensor of the computing device **201** or the objects in the predetermined scene may move in fractional pixel increments. Consequently, the computing device **201** may apply interpolation techniques to determine the sub-pixel motion vector of the current image relative to the reference image. A person of ordinary skill in the art will recognize various techniques for motion estimation. The sub-pixel motion vector may be a two-dimensional vector with each component of the vector having units of 1/N pixel, where N is an integer number. For example, each component of the sub-pixel motion vector may be a half-pixel offset, a third-pixel offset, a quarter-pixel offset, a fifth-pixel offset, a sixth-pixel offset, an eighth-pixel offset, or the like relative to the integer pixel motion vector. In response to the sub-pixel motion vector of the current image of the plurality of images being different from a sub-pixel motion vector of another image of the plurality of images, the computing device **201** may increase the estimated second resolution of the enhanced image. It is important to recognize that a motion vector may include an integer pixel motion vector and a sub-integer pixel motion vector, wherein the sub-integer pixel motion vector is relative to the integer pixel motion vector.

In another embodiment, the computing device **201** may determine an integer-pixel motion vector for a current image of the plurality of images relative to a reference image of the plurality of images. The reference image may be one of the plurality of images. In one example, the reference image may be a first captured image of the plurality of images. In response to the integer pixel motion vector of the current image of the plurality of images being less than a non-stationary threshold, the computing device **201** may increase the estimated second resolution. The non-stationary threshold may be associated with an image sensor of the computing device **201** or objects in the predetermined scene moving during the capture of the current image resulting in the current image not being useful in generating an enhanced image of the predetermined scene.

In another embodiment, the computing device **201** may determine a motion vector for a current image of the plurality of images relative to a reference image of the plurality of images. The reference image may be one of the plurality of images. In one example, the reference image may be a first captured image of the plurality of images. In response to the motion vector of the current image of the plurality of images being less than a non-stationary threshold, the computing device **201** may increase the estimated second resolution. The non-stationary threshold may be associated with an image sensor of the computing device **201** or objects in the predetermined scene moving during the capture of the current image resulting in the current image not being useful in generating an enhanced image of the predetermined scene.

In another embodiment, the computing device **201** may receive an indication of a first action associated with the computing device. In response to the first action, the computing device **201** may enable the continuous image capture of the predetermined scene. In one example, the first action may correspond to a user of the computing device **201** pressing and holding an input device of the computing device **201** associated with a shutter of a camera of the computing device **201** being held open.

In another embodiment, the computing device **201** may receive an indication of a second action associated with the computing device. In response to the second action, the computing device **201** may disable the continuous image capture of the predetermined scene. In one example, the second action may correspond to a user of the computing device **201** releasing an input device of the computing device **201** associated with releasing a shutter of a camera of the computing device **201**.

In another embodiment, the computing device **201** may output, to an image processor, a reference image of the plurality of images. Further, the computing device **201** may output, to the image processor, the current image of the plurality of images. In response to outputting the current image of the plurality of images, the computing device **201** may receive, from the image processor, a motion vector, an integer pixel motion vector or a sub-pixel motion vector of the current image of the plurality of images relative to the reference image of the plurality of images.

In another embodiment, the computing device **201** may output, to the computer **203** using the network **211**, a reference image of the plurality of images. Further, the computing device **201** may output, to the computer **203** using the network **211**, the current image of the plurality of images. In response to outputting the current image of the plurality of images, the computing device **201** may receive, from the computer **203** using the network **211**, a motion vector, an integer pixel motion vector or a sub-pixel motion

vector of the current image of the plurality of images relative to the reference image of the plurality of images.

FIG. **3** is a flowchart of one embodiment of a method **300** for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein. In FIG. **3**, the method **300** may start, for instance, at block **301**, where it may include receiving a first indication associated with continuous image capture of the predetermined scene being enabled. At block **303**, the method **300** may include determining whether the continuous image capture of the predetermined scene is enabled. If the continuous image capture of the predetermined scene is enabled, at block **305**, the method **300** may include receiving, from a sensor such as an image sensor, a current image of the plurality of images of the predetermined scene. Each of the plurality of images may have a first resolution. At block **315**, the method **300** may include updating an estimated second resolution of the enhanced image using the current image of the plurality of images. The estimated second resolution of the enhanced image may be at least the first resolution. At block **317**, the method **300** may include outputting, for display, the estimated second resolution of the enhanced image. If the continuous image capture of the predetermined scene is disabled, at block **319**, the method **300** may include generating an enhanced image using the plurality of images, associating the enhanced image with one of the plurality of images, or the like. Further, the enhanced image may have a second resolution that is at least the first resolution and about the estimated second resolution.

In another embodiment, a method may include receiving a first indication associated with continuous image capture of a predetermined scene being enabled. In one example, the first indication may correspond to a user of the computing device pressing and holding an input device such as a button or a presence-sensitive display of the computing device. In response to the first indication, the method may include enabling the continuous image capture of the predetermined scene.

In another embodiment, a method may include receiving a second indication associated with the continuous image capture of the predetermined scene being disabled. In one example, the second indication may correspond to a user of the computing device releasing the input device of the computing device. In response to the second indication, the method may include disabling the continuous image capture.

In another embodiment, a method may include outputting, to an image processor, the plurality of images. In response, the method may include receiving, from the image processor, the enhanced image.

In another embodiment, a method may include outputting, to a computer such as over a network, the plurality of images. In response, the method may include receiving, from the computer, the enhanced image.

In another embodiment, each of the plurality of images may be a sequential image of the predetermined scene.

In another embodiment, each of the plurality of images may be a raw image.

In another embodiment, a method may include determining a sub-pixel motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. In response to the sub-pixel motion vector of the current image of the plurality of images being different from a sub-pixel motion vector of a previous image of the plurality of images, the method may include increasing the estimated second resolution of the enhanced image. Each sub-pixel motion vector of the plurality of images may be relative to a reference image of the plurality of images.

In another embodiment, a method may include outputting, to an image processor, a reference image of the plurality of reference images. Further, the method may include outputting, to an image processor, the current image of the plurality of images. In response to outputting, the current image of the plurality of images, the method may include receiving, from the image processor, a motion vector, an integer pixel motion vector, or a sub-pixel motion vector of the current image of the plurality of images relative to the reference image of the plurality of images.

In another embodiment, a method may include determining a stab-pixel motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. In response to the sub-pixel motion vector of the current image of the plurality of images being less than a non-stationary threshold, the method may include increasing the estimated second resolution of the enhanced image.

In another embodiment, a method may include increasing the estimated second resolution of the enhanced image by the first resolution.

In another embodiment, a method may include increasing the estimated second resolution of the enhanced image by a predetermined resolution associated with the first resolution. In one example, the predetermined resolution may be N times the first resolution, wherein N is a whole number. In another example, the predetermined resolution may be configurable by a user of a computing device.

In another embodiment, a method may include, in response to determining that the estimated second resolution of the enhanced image is at least a predetermined resolution disabling the continuous image capture.

In another embodiment, a method may include, response to determining that the continuous capture is performed for a predetermined duration, disabling the continuous image capture. In one example, the predetermined duration may be about one (1) second. In another example, the predetermined duration may be in the range of about one hundred milliseconds (100 msec.) to about five (5) seconds.

In another embodiment, a method may include determining a sub-pixel motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. In response to the sub-pixel motion vector of the current image of the plurality of images being associated with a sub-pixel motion vector of a previous image of the plurality of images, the method may include removing the current image from the plurality of images. Each sub-pixel motion vector of the plurality of images may be relative to the reference image of the plurality of images.

In another embodiment, a method may include, in response to determining that a current image of the plurality of images is non-stationary, disabling the continuous image capture.

In another embodiment, a method may include, in response to determining that a current image of the plurality of images is non-stationary, removing the current image from the plurality of images.

In another embodiment, a method may include determining an integer pixel motion vector for a current image of the plurality of images relative to a reference image of the plurality of images. Further, the method may include determining that the integer pixel motion vector of the current image of the plurality of images is at least a non-stationary threshold. In response, the method may include disabling the

continuous image capture, removing the current image from the plurality of images, or the like.

In another embodiment, the sensor may be an image sensor.

In another embodiment, a method may include determining a sub-pixel motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. The method may include decomposing all or a portion of the current image of the plurality of images into image blocks, which may also be referred to as macroblocks. In one example, the image block may be four (4) pixels by four (4) pixels, eight (8) pixels by eight (8) pixels, sixteen (16) pixels by sixteen (16) pixels, or the like. In another example, an image may be an image block. The method may include determining for each image block of the current image a best match to an image block of the reference image. The two-dimensional coordinate shift of each image block of the current image relative to a best image block of the reference image may determine an integer pixel motion vector for the current image. However, during the continuous image capture, an image sensor of a computing device, objects in the predetermined scene, or the like may not move in exact integer pixel increments. Instead, the image sensor of the computing device or the objects in the predetermined scene may move in fractional pixel increments. Consequently, the method may include applying interpolation techniques to determine the sub-pixel motion vector of the current image block relative to the reference image block. A person of ordinary skill in the art will recognize various techniques for performing motion estimation. The sub-pixel motion vector may be a two-dimensional vector with each component of the vector having units of 1/N pixel, where N is an integer number. For example, each component of the sub-pixel motion vector may be a half-pixel offset, a third-pixel offset, a quarter-pixel offset, a fifth-pixel offset, a sixth-pixel offset, an eighth-pixel offset, or the like relative to the integer pixel motion vector. In response to the sub-pixel motion vector of the current image of the plurality of images being different from a sub-pixel motion vector of another image of the plurality of images, the method may include increasing the estimated second resolution of the enhanced image. It is important to recognize that a motion vector may include an integer pixel motion vector and a sub-integer pixel motion vector, wherein the sub-integer pixel motion vector is relative to the integer pixel motion vector.

FIG. **4** is a flowchart of another embodiment of a method **400** for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein. In FIG. **4**, the method **400** may start, for instance, at block **401**, where it may include receiving a first indication associated with continuous image capture of the predetermined scene being enabled. At block **403**, the method **400** may include determining whether the continuous image capture of the predetermined scene is enabled. If the continuous image capture of the predetermined scene is enabled, at block **405**, the method **400** may include receiving, from a sensor such as an image sensor, a current image of the plurality of images associated with the predetermined scene. Each of the plurality of images may have a first resolution. At block **409**, the method may include determining whether the current image of the plurality of images is non-stationary. If the current image of the plurality of images is stationary, at block **415**, the method **400** may include updating an estimated second resolution of the enhanced image of the predetermined scene using the current image of the plurality of images. The second resolution of the enhanced image may be at least the first resolution. At block **417**, the method **400** may include outputting, for display, the estimated second resolution of the enhanced image. If the continuous image capture of the predetermined scene is disabled or the current image of the plurality of images is non-stationary, at block **419**, the method **400** may include generating an enhanced image of the predetermined scene using a plurality of images, associating the enhanced image of the predetermined scene with one of the plurality of images, or the like. Further, the enhanced image has a second resolution that may be at least the first resolution and about the estimated second resolution.

FIG. **5** is a flowchart of another embodiment of a method **500** for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein. In FIG. **5**, the method **500** may start, for instance, at block **501**, where it may include receiving a first indication associated with continuous image capture of the predetermined scene being enabled. At block **503**, the method **500** may include determining whether the continuous image capture of the predetermined scene is enabled. If the continuous image capture of the predetermined scene is enabled, at block **505**, the method **500** may include receiving, from a sensor such as an image sensor, a current image of the plurality of images associated with the predetermined scene. Each of the plurality of images may have a first resolution. At block **507**, the method **500** may include determining a current motion vector for the current image of the plurality of images relative to a reference image of the plurality of images. Each motion vector of the plurality of images may be determined relative to the reference image of the plurality of images.

In FIG. **5**, at block **509**, the method **500** may include determining whether the current motion vector of the current image of the plurality of images is at least a non-stationary threshold. If the current motion vector is at least the non-stationary threshold, at block **510**, the method **500** may include removing the current image from the plurality of images. Otherwise, if the current motion vector is less than the non-stationary threshold, at block **511**, the method **500** may include determining whether the sub-pixel motion vector of the current image of the plurality of images is the same as a sub-pixel motion vector of another image of the plurality of images. If the current sub-pixel motion vector is the same as the sub-pixel motion vector of the other image, at block **512**, the method **500** may include removing one of the current image and the other image from the plurality of images. In one example, the method **500** may include removing the other image having the same sub-pixel motion vector from the plurality of images. In another example, the method **500** may include removing the current image having the same sub-pixel motion vector from the plurality of images. In another example, the method **500** may include comparing the current image having the same sub-pixel motion vector to the reference image to generate a first difference. Further, the method **500** may include comparing the other image having the same sub-pixel motion vector to the reference image to generate a second difference. Finally, in response to determining that the first difference is less than the second difference, the method **500** may include removing the other image from the plurality of images.

Otherwise, if the current sub-pixel motion vector is different from the other sub-pixel motion vectors, at block **515**, the method **500** may include updating an estimated second resolution of an enhanced image of the predetermined scene using the current image of the plurality of images. The

second resolution of the enhanced image may be at least the first resolution. At block **517**, the method **500** may include outputting, for display, the estimated second resolution of the enhanced image and may return to block **503**. If the continuous image capture of the predetermined scene is disabled, at block **519**, the method **500** may include generating the enhanced image of the predetermined scene using the plurality of images, may associate the enhanced image of the predetermined scene with one of the plurality of images, or the like. The enhanced image may have a second resolution that is at least the first resolution and about the estimated second resolution. The method **500** may include generating the enhanced image by aligning and combining the plurality of images so that additional image information is obtained.

In another embodiment, a method may include determining a motion vector for each image block of a current image relative to a reference image. The method may include determining whether the motion vector of each image block of the current image is at least a non-stationary threshold. If the motion vector of a particular image block is at least the non-stationary threshold, the method may include removing the particular image block from the current image. By performing such method using image blocks may reduce the impact of, for instance, a bird flying through a predetermined scene.

In another embodiment, a method may include determining a motion vector for each image block of the current image relative to a reference image. The method may include determining whether the sub-pixel motion vector of the particular image block of the current image is the same as a sub-pixel motion vector of a corresponding image block of another image. If the sub-pixel motion vector of the particular image block of the current image is the same as the sub-pixel motion vector of the corresponding image block of the other image, the method may include removing one of the particular image block of the current image and the corresponding image block of the other image. In one example, the method may include removing the corresponding image block having the same sub-pixel motion vector from the other image. In another example, the method may include removing the particular image block having the same sub-pixel motion vector from the current image. In another example, the method may include comparing the particular image block of the current image to a corresponding image block of the reference image to generate a first difference. Further, the method may include comparing the corresponding image block of the other image to the corresponding image block of the reference image to generate a second difference. Finally, in response to determining that the first difference is less than the second difference, the method may include removing the corresponding image block from the other image.

In another embodiment, a method may include updating an estimated second resolution of an enhanced image of the predetermined scene using one or more image blocks of a current image.

In another embodiment, a method may include generating an enhanced image of the predetermined scene using image blocks of a plurality of images. Further, the method may include generating the enhanced image by aligning and combining the image blocks of the plurality of images using their motion vectors so that additional image information is obtained.

In another embodiment, a method may include, in response to determining that the current motion vector of the current image of the plurality of images is at least the non-stationary threshold, disabling the continuous image capture of the predetermined scene.

FIG. **6** is a flowchart of another embodiment of a method **600** for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene with various aspects described herein. In FIG. **6**, the method **600** may start, for instance, at block **601**, where it may include receiving a plurality of images of the predetermined scene. Each of the plurality of images may have a first resolution. At block **603**, the method **600** may determine a reference image from the plurality of images. At block **605**, the method **600** may determine a motion vector for each image of the plurality of images relative to the reference image of the plurality of images. The motion vector may include an integer pixel motion vector and a sub-pixel motion vector. At block **607**, the method **600** may include determining whether any motion vectors of the plurality of images is at least a non-stationary threshold. At block **609**, the method **600** may include removing each image having a non-stationary motion vector from the plurality of images. At block **611**, the method **600** may include determining whether any of the plurality of images has the same sub-pixel motion vector. If any of the plurality of images has the same sub-pixel motion vector, at block **613**, the method **600** may include selecting one of the plurality of images having the same sub-pixel motion vector. Further, at block **615**, the method **600** may include removing the other images having the same sub-pixel motion vector from the plurality of images.

In FIG. **6**, at block **617**, the method **600** may include aligning and combining the plurality of images using their motion vectors to generate an enhanced image. The method **600** may use the motion vector of each of the plurality of images to align itself relative to the reference image of the plurality of images. Further, the method **600** may need to radially align one or more of the plurality of images relative to the reference image of the plurality of images. A person of ordinary skill will recognize various techniques for aligning and combining the plurality of images using motion vectors. After aligning and combining the plurality of images using the motion vectors to form an enhanced image, the method **600** may include determining that the enhanced image has empty pixel locations or sub-pixel locations. In response, at block **619**, the method **600** may perform interpolation using surrounding pixel locations or sub-pixel locations to determine the empty pixel locations or the empty sub-pixel locations. In one example, the method **600** may use non-adaptive interpolation algorithms such as nearest neighbor, bilinear, bicubic, spline, sinc, lanczos, or the like. In another example, the method **600** may use adaptive interpolation algorithms to minimize interpolation artifacts. A person of ordinary skill will recognize various techniques for interpolating an image.

FIG. **7** provides an example of a two-dimensional grid **700** used to generate an enhanced image of a predetermined scene from a plurality of images of the predetermined scene in accordance with various aspects described herein. Each of the plurality of images may have a first resolution. In FIG. **7**, the grid **700** of the enhanced image may include about four (4) times more pixel locations than each of the plurality of images. Thus, a second resolution of the enhanced image may be up to about four (4) times greater than the first resolution of each of the plurality of images. An ordinate **701** describes a first dimension of the grid **700** such as a y-axis or a vertical axis. An abscissa **703** describes a second dimension of the grid **700** such as an x-axis or a horizontal axis. A reference image **705** of the plurality of images may

be positioned on the grid **700** at, for instance, integer pixel locations. A first image **707** of the plurality of images with a first motion vector **717** having a half pixel offset along the abscissa **703** relative to the reference image **705** may be positioned on the grid **700**. Further, a second image **709** of the plurality of images with a second motion vector **719** having a one and a half pixel offset along the ordinate **701** and a half pixel offset along the abscissa **703** relative to the reference image **705** may be positioned on the grid **700**. A pixel value for each empty pixel location or sub-pixel location may be determined by performing interpolation using pixel values of surrounding pixel or sub-pixel locations to generate the interpolated pixels **711**.

FIG. **8** provides another example of a two-dimensional grid **800** used to generate an enhanced image of a predetermined scene from a plurality of images of the predetermined scene in accordance with various aspects described herein. Each of the plurality of images may have a first resolution. In FIG. **8**, the grid **800** of the enhanced image may include about sixteen (16) times more pixel locations than each of the plurality of images. Thus, the second resolution of the enhanced image may be up to about sixteen (16) times greater than the first resolution of each of the plurality of images. Further, the enhanced image may be composed of a plurality of image blocks. An ordinate **801** describes a first dimension of the grid **800** such as a y-axis or a vertical axis. An abscissa **803** describes a second dimension of the grid **800** such as an x-axis or a horizontal axis. An image block **805** of a plurality of image blocks of a reference image may be positioned on the grid **800**. An associated image block **807** of a plurality of image blocks of a first image with a first motion vector **817** having a one and a quarter pixel offset along the abscissa **803** relative to the reference image block **805** may be positioned on the grid **800**. Further, an associated image block **809** of a plurality of image blocks of a second image with a second motion vector **819** having a negative quarter pixel offset along the ordinate **801** and a negative quarter pixel offset along the abscissa **803** relative to the reference image block **805** may be positioned on the grid **800**. Further, an associated image block **811** of a plurality of image blocks of a third image with a third motion vector **821** having a quarter pixel offset along the ordinate **801** and a half pixel offset along the abscissa **803** relative to the reference image block **805** may be positioned on the grid **800**. After aligning and combining the images, a pixel value for each empty pixel location or sub-pixel location may be determined by performing interpolation using pixel values of surrounding pixel or sub-pixel locations to generate the interpolated pixels **813**.

In another embodiment, a number of a plurality of images of a predetermined scene may be used to determine a size of the enhanced image.

In another embodiment, a number of a plurality of images of a predetermined scene may be used to determine an interpolation rate of a reference image of the plurality of images.

It is important to recognize that it is impractical to describe every conceivable combination of components or methodologies for purposes of describing the claimed subject matter. However, a person having ordinary skill in the art will recognize that many further combinations and permutations of the subject technology are possible. Accordingly, the claimed subject matter is intended to cover all such alterations, modifications and variations that are within the spirit and scope of the claimed subject matter.

In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art will appreciate that various modifications and changes may be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings. The benefits, advantages, solutions to (problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. This disclosure is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has," "having," "includes," "including," "contains," "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises . . . a," "has . . . a," "includes . . . a," "contains . . . a" or the like does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a," "an," and "the" are defined as one or more unless explicitly stated otherwise herein. The term "or" is intended to mean an inclusive "or" unless explicitly stated otherwise herein. The terms "substantially," "essentially," "approximately," "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

Furthermore, the term "connected" means that one function, feature, structure, component, element, or characteristic is directly joined to or in communication with another function, feature, structure, component, element, or characteristic. The term "coupled" means that one function, feature, structure, component, element, or characteristic is directly or indirectly joined to or in communication with another function, feature, structure, component, element, or characteristic. References to "one embodiment," "an embodiment," "example embodiment," "various embodiments," and other like terms indicate that the embodiments of the disclosed technology so described may include a particular function, feature, structure, component, element, or characteristic, but not every embodiment necessarily includes the particular function, feature, structure, component, element, or characteristic. Further, repeated use of the phrase "in one embodiment" does not necessarily refer to the same embodiment, although it may.

It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program

instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches may be used. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

The Abstract is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

This detailed description is merely illustrative in nature and is not intended to limit the present disclosure, or the application and uses of the present disclosure. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding field of use, background, or this detailed description. The present disclosure provides various examples, embodiments and the like, which may be described herein in terms of functional or logical block elements. Various techniques described herein may be used for generating an enhanced image of a predetermined scene from a plurality of images of the predetermined scene. The various aspects described herein are presented as methods, devices (or apparatus), systems, or articles of manufacture that may include a number of components, elements, members, modules, nodes, peripherals, or the like. Further, these methods, devices, systems, or articles of manufacture may include or not include additional components, elements, members, modules, nodes, peripherals, or the like. Furthermore, the various aspects described herein may be implemented using standard programming or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computing device to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computing device, carrier, or media. For example, a non-transitory computer-readable medium may include: a magnetic storage device such as a hard disk, a floppy disk or a magnetic strip; an optical disk such as a compact disk (CD) or digital versatile disk (DVD); a smart card; and a flash memory device such as a card, stick or key drive. Additionally, it should be appreciated that a carrier wave may be employed to carry computer-readable electronic data including those used in transmitting and receiving electronic data such as electronic mail (email) or in accessing a computer network such as the Internet or a local area network (LAN). Of course, a person of ordinary skill in the art will recognize many modifications may be made to this configuration without departing from the scope or spirit of the claimed subject matter.

What is claimed is:

**1**. A method, comprising:

receiving a plurality of images of a predetermined scene, wherein each of the plurality of images has a first resolution;

determining a reference image from the plurality of images;

determining a sub-pixel motion vector for each of the plurality of images relative to the reference image;

aligning and combining pixels from the plurality of images using corresponding sub-pixel motion vectors to form an enhanced image; and

in response to identifying an empty sub-pixel location in the enhanced image, interpolating the enhanced image to determine a pixel value for the empty sub-pixel location.

**2**. The method of claim **1**, further comprising:

removing one of two of the plurality of images responsive to two of the plurality of images having a same sub-pixel motion vector.

**3**. The method of claim **1**, further comprising:

responsive to any of the plurality of images being association with motion of subject matter in the predetermined scene, removing a corresponding image.

**4**. The method of claim **1**, wherein capture of the plurality of images is initiated by a user depressing a button of a camera and capture of the plurality of images ends when the user releases the button of the camera.

**5**. The method of claim **1**, wherein capture of the plurality of images is initiated by a user providing input to a presence-sensitive input device and capture of the plurality of images ends when the user stops providing the input to the presence-sensitive input device.

**6**. The method of claim **1**, wherein determining the sub-pixel motion vector for each of the plurality of images relative to the reference image includes:

decomposing at least a portion of each of the plurality of images into macroblocks, wherein each macroblock includes a set of pixels;

determining, for each macroblock, a best match to an image block of the reference image; and

performing interpolation to determine the sub-pixel motion vector.

**7**. The method of claim **1**, wherein determining the reference image from the plurality of images includes a first captured image of the plurality of images.

**8**. The method of claim **1**, further comprising:

responsive to a first sub-pixel motion vector for a current image of the plurality of images being different from a second sub-pixel motion vector, increasing a second resolution for the enhanced image.

**9**. A portable communication device, comprising:

a memory configured to store data and computer-executable instructions; and

a processor operatively coupled to the memory, wherein the processor is configured to:

receive a plurality of images of a predetermined scene;

determine a reference image from the plurality of images;

determine a sub-pixel motion vector for each of the plurality of images relative to the reference image;

align and combine pixels from the plurality of images using corresponding sub-pixel motion vectors to form an enhanced image; and

in response to identifying an empty sub-pixel location in the enhanced image, interpolate the enhanced image to determine a pixel value for the empty sub-pixel location.

**10**. The portable communication device of claim **9**, wherein the processor is further configured to:

remove one of two of the plurality of images responsive to two of the plurality of images having a same sub-pixel motion vector.

**11**. The portable communication device of claim **9**, wherein the processor is further configured to:

responsive to any of the plurality of images being association with motion of subject matter in the predetermined scene, remove a corresponding image.

**12**. The portable communication device of claim **9**, wherein capture of the plurality of images is initiated by a user depressing a button of a camera and capture of the plurality of images ends when the user releases the button of the camera.

**13**. The portable communication device of claim **9**, wherein capture of the plurality of images is initiated by a user providing input to a presence-sensitive input device and capture of the plurality of images ends when the user stops providing the input to the presence-sensitive input device.

**14**. The portable communication device of claim **9**, wherein determining the sub-pixel motion vector for each of the plurality of images relative to the reference image includes:

decomposing at least a portion of each of the plurality of images into macroblocks, wherein each macroblock includes a set of pixels;

determining, for each macroblock, a best match to an image block of the reference image; and

performing interpolation to determine the sub-pixel motion vector.

**15**. The portable communication device of claim **9**, wherein determining the reference image from the plurality of images includes a first captured image of the plurality of images.

**16**. A non-transitory computer readable medium with instructions stored thereon that, when executed by one or more computers, cause the one or more computers to perform operations, the operations comprising:

receiving a plurality of images of a scene, wherein each of the plurality of images has a resolution;

determining a reference image from the plurality of images;

determining a sub-pixel motion vector for each of the plurality of images relative to the reference image;

aligning and combining pixels from the plurality of images using corresponding sub-pixel motion vectors to form an enhanced image; and

in response to identifying an empty sub-pixel location in the enhanced image, interpolating the enhanced image to determine a pixel value for the empty sub-pixel location.

**17**. The computer-readable medium of claim **16**, wherein the operations further comprise:

removing one of two of the plurality of images responsive to two of the plurality of images having a same sub-pixel motion vector.

**18**. The computer-readable medium of claim **16**, wherein the operations further comprise:

responsive to any of the plurality of images being association with motion of subject matter in the scene, removing a corresponding image.

**19**. The computer-readable medium of claim **16**, wherein capture of the plurality of images is initiated by a user depressing a button of a camera and capture of the plurality of images ends when the user releases the button of the camera.

**20**. The computer-readable medium of claim **16**, wherein capture of the plurality of images is initiated by a user providing input to a presence-sensitive input device and capture of the plurality of images ends when the user stops providing the input to the presence-sensitive input device.

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